

EXPEDITION 'JOB 74'

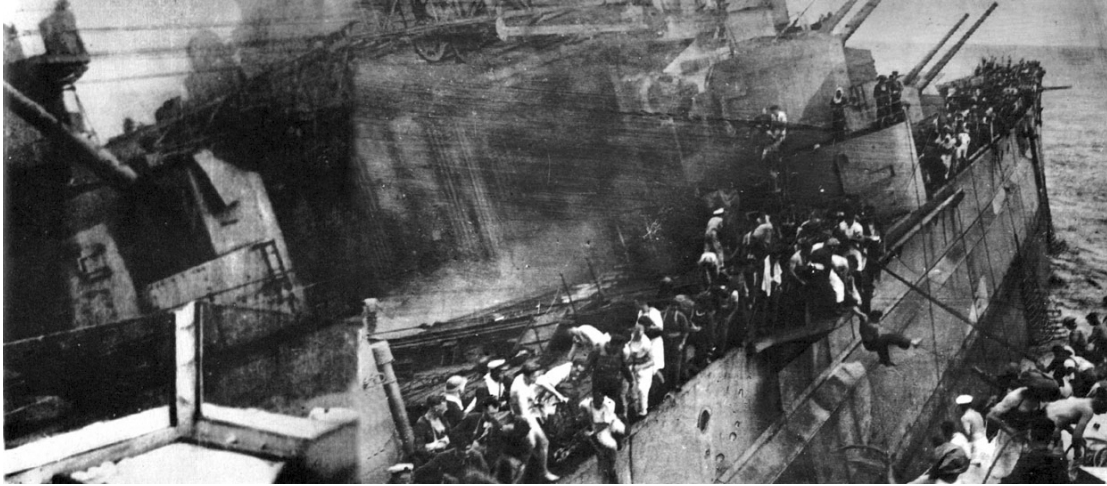
An overview of Expedition 'Job 74' which carried Explorers Club Flag #118 to the wrecks of HMS *Prince of Wales* and HMS *Repulse*, South China Sea, May 13th – May 25th 2007.

Report compiled and submitted by expedition member and flag applicant Kevin Denlay, Fellow International 1998. (Page 1 of 28)



“They shall not grow old, as we that are left grow old. Age shall not weary them, nor the years condemn. At the going down of the sun and in the morning we shall remember them.”

EXPEDITION 'JOB 74'



Looking forward along Stbd side of *Prince of Wales* moments before she capsized to Port.

THE IMPERIAL JAPANESE NAVY'S SHIP-KILLER AIRCRAFT



Mitsubishi G3M Type 96 Rikko: Allied code name '*Nell*', carried either bombs or torpedoes in the attack (i.e. 34 carried bombs and 17 carried torpedoes).



Mitsubishi G4M Type 1 Rikko: Allied code name '*Betty*', all 26 carried torpedoes.

EXPEDITION 'JOB 74'

PREAMBLE

The two British capital ships of Force Z, HMS *Prince of Wales* and HMS *Repulse* – a battleship and a battle cruiser respectively - were sunk by Japanese aircraft in the South China Sea off the east coast of Malaysia on December 10, 1941, just days after the Japanese attack on Pearl Harbour. Notably, they were the first capital ships to be sunk solely by air attack whilst underway at sea and fully prepared for action. Their dramatic sinking with significant loss of life (327 men from *Prince of Wales* and 436 men from *Repulse*) spelled the end of the battleship era and ascendancy of air power, which subsequently lead to the aircraft carrier dominating the war at sea. (HMS *Prince of Wales* and HMS *Repulse* are designated War Graves and hence deserve respect when diving.)

Job 74, from which the expedition took its name, were a series of exhaustive underwater explosive tests carried out during the mid 1930's by the British Royal Navy to determine (and supposedly 'confirm') that the protective design system to be incorporated into the hull of their most modern class of battleship soon to begin construction - the King George V Class - of which *Prince of Wales* was one, was impervious to torpedo damage. However, in the very first 'real life' test, the anti-torpedo protection system incorporated into the hull of *Prince of Wales* as a result of Job 74 proved woefully inadequate.

Both wrecks now lay upside down, or virtually upside down, *Prince of Wales* even more so than *Repulse*, and in 68m/223ft and 54m/177ft of water respectively. Over the years since their sinking there has been much conjecture and debate as to exactly how many torpedoes actually hit the two ships, from the overly optimistic claims of the Japanese air crews, to the more moderate and generally accepted reports of the British survivors themselves. My intention, and my main task on the expedition, was to concentrate on recording video footage along the hulls of both *Prince of Wales* and *Repulse* so as to ascertain exactly how many torpedo holes there actually are in both hulls and exactly where they are located. The resultant video footage would then be provided to historians, etc, as 'physical evidence' of the hits themselves, and to 'back-up' any discrepancies the expedition might find as to what's contained in the historical record with regards the overall number of torpedo hits and the actual damage sustained.

A total of eight Closed Circuit Rebreather (CCR) divers would take part in the overall expedition, although only three of those, expedition leader Dr Andrew Fock, his dive partner retired Royal Navy officer Graham Sharpe Paul, and I, would actually participate in the hull survey itself. All divers would however participate in two associated medical tests conducted by Dr Fock, a hyperbaric physician from The Alfred Hospital, Melbourne, Australia.

All expedition members traveled from Australia to Singapore in mid May 2007 where we boarded the dive vessel MV *Empress* which we had chartered for our expedition to the wrecks. We then spent a total of ten days out in the South China Sea, which allowed for four days of diving on each of the two wrecks, with a day needed to travel up to the wrecks from Singapore and a day of travel to return to Singapore. All dives were conducted using helium based breathing mixtures and required extensive decompression, the final stages of which were conducted on a purpose built 'decompression station' suspended under the dive vessel with surface supplied oxygen available from 6m/20ft.

EXPEDITION ‘JOB 74’

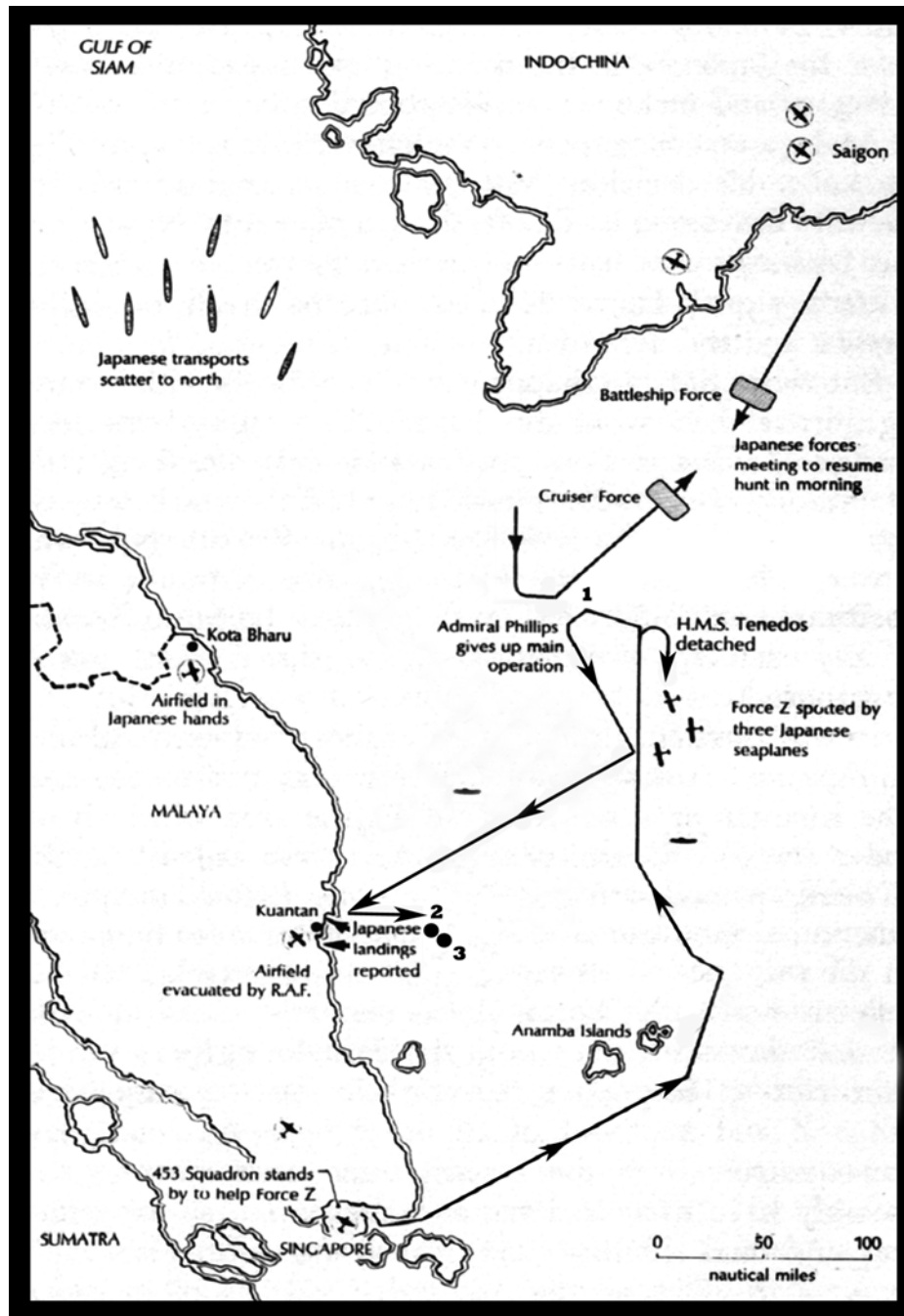
EXPEDITION OBJECTIVES

- 1) Survey the hulls of both vessels using video cameras to ascertain exactly how many torpedo holes are actually in each ship and exactly where they are located. It was also hoped that besides providing the subsequent footage to interested historians, information garnered from viewing this footage could be used to definitively illustrate 3D models of the upturned vessels showing exactly where the hits are on the hulls, rather than where there are ‘thought to have been’.
- 2) Use a ‘look down, shoot down’ video filming technique – with a video camera mounted vertically on the front of a diver propulsion vehicle (i.e. scooter) - to gather footage of the wrecks, ‘from above’ as it were, that would be then used to make a photographic mosaic of both ships as they now lay.
- 3) Daily testing/recording of all divers on the expedition, even those not directly involved with the hull survey itself, for symptoms of Hyperoxia Induced Myopia (HIM) by Dr Andrew Fock using a Snellen chart and various strength diopter lenses. (As stated previously, all divers were diving using Closed Circuit Rebreathers which hold a constant partial pressure of oxygen during the dive, and were decompressing on 100% oxygen from 6m/20ft and above, both factors which are known to contribute to HIM, especially when conducting long deep dives over multi day periods as the divers on this expedition were doing.)
- 4) Daily testing/recording of all divers on the expedition, even those not directly involved with the hull survey itself (again by Dr Andrew Fock and using a Spirometer) for symptoms of Pulmonary Oxygen Toxicity, another side effect when diving using constant partial pressure CCR’s and decompressing on 100% oxygen over a multi dive/day period as the divers on this expedition were doing.

Expedition members	Rebreather model used
Andrew Fock	Inspiration CCR
Les Rothbart	Inspiration CCR
Andrew McIntosh	Inspiration CCR
Ian Brice	Inspiration CCR
Jim Moroukis	Inspiration CCR
Graham Sharpe Paul	Evolution CCR
Mike Campbell	Prism CCR
Kevin Denlay	Mk15.5 CCR

After arriving ‘on site’ we spent the first four days diving on HMS *Repulse* and the subsequent four days diving on HMS *Prince of Wales*, which lays approximately nine nautical miles southeast from the wreck of *Repulse*. Disappointingly, while the surface conditions were literally perfect for our whole time at sea, with calm ‘glassy’ conditions each day, the visibility on *Repulse* was poor to begin with and it continued to deteriorate, literally on a daily basis, as the expedition progressed and we moved over to *Prince of Wales*. Given the depth of the dives, the poor visibility, the strong currents at times and the sheer magnitude of the wrecks themselves (*Repulse* is 242m/794ft overall and *Prince of Wales* is 227m/745ft overall), it made for ‘challenging’ conditions to say the least.

EXPEDITION 'JOB 74'



Force Z's route, from leaving Singapore on evening of 8th December until late morning on 10th December. At the time when Force Z 'turned away' south, when at it's northern most point (1), neither fleet knew at the time just how close they had come to one another. Black Dot 2, about sixty nautical miles off Kuantan, marks the location of the wreck of HMS *Repulse*; while Black Dot 3 marks the wreck location of HMS *Prince of Wales*, about nine nautical miles distant from *Repulse*. As Lt. Cmdr. Cain of the escorting destroyer HMS *Electra* said, "It was a bold scheme.....if it had come off as planned it might have changed the course of history; that it didn't come off is one of the saddest tragedies of our time". (The above chart is a modified version of one found in *Battleships: Allied Battleships of World War 11* by W Garzke and R Dulin, and is used with permission.)

EXPEDITION 'JOB 74'

Results of Objective 1 on HMS *Repulse*

Repulse is the shallower of the two wrecks, resting almost upside down in 54m/177ft of water, although the starboard deck edge itself is 'held up' well off the seabed by parts of *Repulse's* forward superstructure protruding from under the wreck out across the seabed, with the elevation of the deck edge (or the 'tilt' of the deck off the seabed as it were) tapering off gradually until the stern of the ship is basically flush with the seabed. Hence this 'elevation' along much of the starboard side of the wreck has tended to have pushed – for want of a better word – or 'orientated' *Repulse's* port side hull down *into* the seabed, especially in the amidships area. As a result the sand has built up to such an extent that much of the port hull amidships is now completely hidden/buried beneath the seabed itself. (This, as it turned out, seriously hindered part of our survey.)

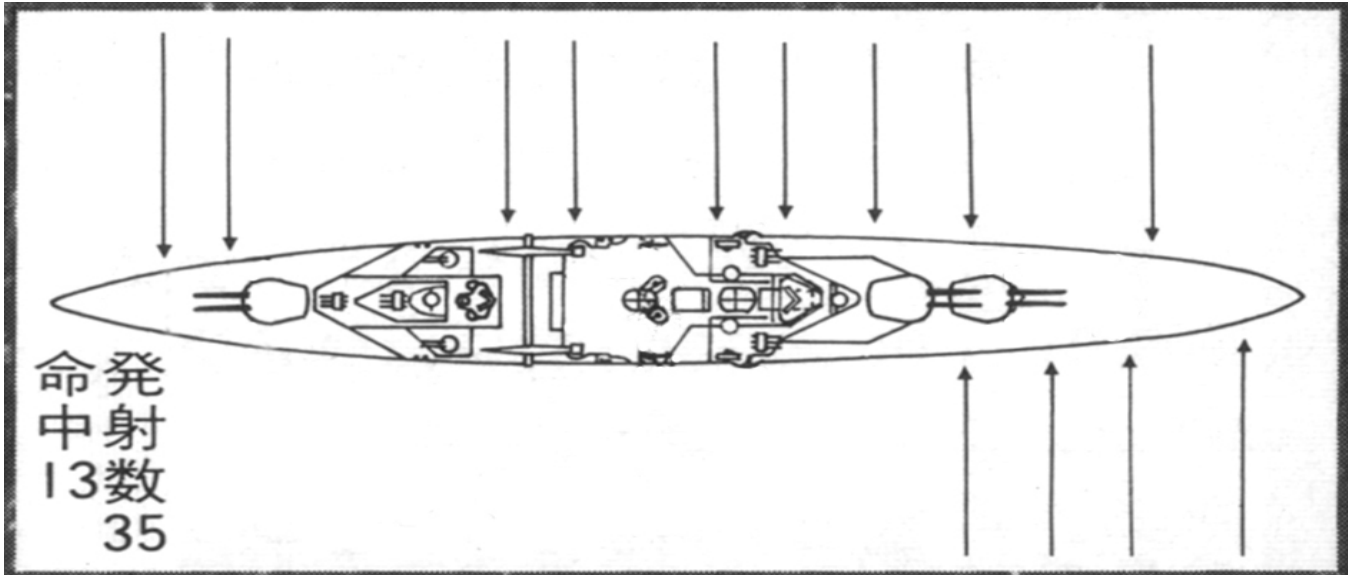
British accounts state that HMS *Repulse* was thought to have been hit by five torpedoes, with four hits in various places along the port side and one hit amidships on the starboard side. Our expedition could only confirm the hit amidships to starboard and one of the hits to port (beneath the port inner propeller) but could not locate any of the other three reported hits to port even though I did 'video runs' along the port side hull on separate dives specifically looking for these hits/holes.

However part of the reason for not seeing two of the hits/holes could be that where these two hits were reported to have been, port amidships, the sand/seabed has built up to such an extent against the hull in this area as to have covered any actual torpedo holes that may be there. There was some evidence in two areas along the port hull amidships, right on the seabed, where there was what appeared to be some 'dimpling' or crumpling of the hull, but no evidence of actual jagged penetrating holes, as can be seen say starboard amidships. There could be times however when the ocean currents scour the sand out 'deeper' along the port side hull, resulting in exposing a greater expanse of the hull side itself for investigation around these 'dimpled' areas, but while we were on site there was only about 2.5m/8ft of hull showing between the port bilge keel and the seabed amidships. Therefore any torpedo holes that may have been higher on the port hull itself in this area would have been buried (hidden) under the actual seabed.

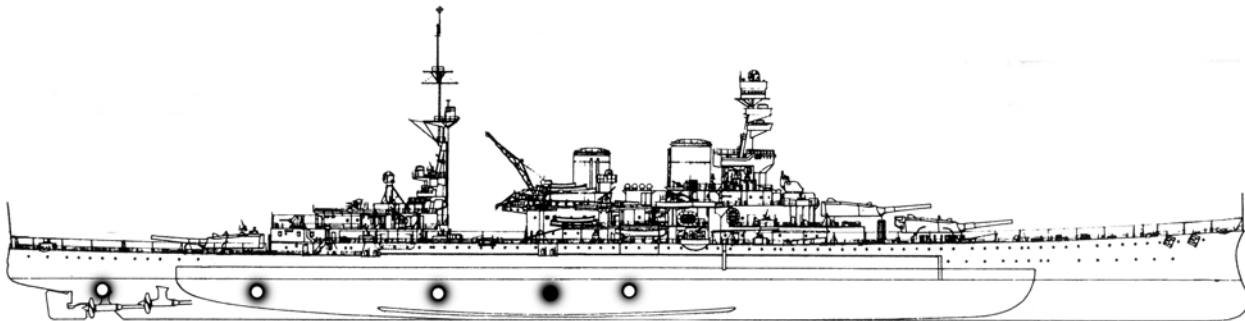
It should be noted however that the other, or fourth 'reported' torpedo hit to port towards the stern, supposedly abreast Y turret - an area where the seabed/sand has *not* built up against the hull to any great extent and hence which should have left any hole clearly visible - was simply *not* seen to be there.

We spent four days diving on *Repulse*, with the visibility steadily deteriorating on a daily basis; which did not bode well for - and subsequently proved to be the case - on our next target, HMS *Prince of Wales*. (On both wrecks two dives a day were conducted by most members of the expedition, with each divers bottom time - i.e. the time spent actually on the wreck - ranging from thirty to fifty minutes, which resulted in total in-water time - or 'run times' including decompression - of between one and half and three hours per dive.)

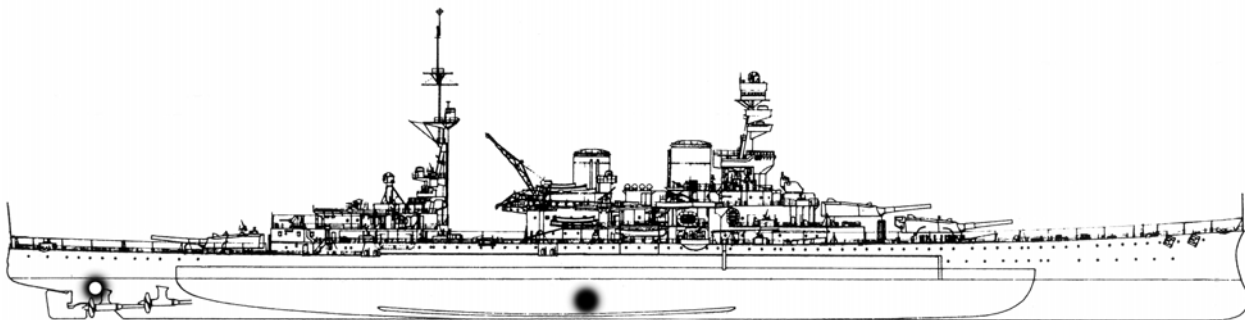
EXPEDITION 'JOB 74'



Arrows indicate where Japanese aircrews thought 13 of the 35 torpedoes launched at HMS *Repulse* hit. (Above diagram as reported by Japanese sources.)



British sources record only five torpedo hits, as shown above.
Black solid circle on hull = Suspected starboard side torpedo hit.
Black outline circles on hull = Suspected port side torpedo hits.



Expedition 'Job 74' could confirm only two hits as shown, although as stated previously the two port side amidships hits *may* have been buried beneath the seabed at the time the expedition was conducted. However, the suspected hit abreast the rear turret is *not* there.
Black solid circle on hull = Confirmed starboard side torpedo hit.
Black outline circle on hull = Confirmed port side torpedo hit.

EXPEDITION 'JOB 74'

The confirmed location of two hits



3D image of HMS *Repulse* courtesy Stefan Draminski



Photo is of the starboard amidships hit on *Repulse*, which is approx 4m high x 6m wide. Top left and right can just be seen the remains of the destroyed bilge keel. (NOTE; the distortion/curvature seen at the bottom of photo is from the use of a Fisheye - 180° - lens.)

EXPEDITION 'JOB 74'

Results of Objective 1 on HMS *Prince Of Wales*

Prince of Wales also rests upside down (even more so than *Repulse*) in 68m/223ft of water with, again, the starboard deck edge held up off the seabed but in this case by only about 5.5m/18ft in the amidships area - which is much less 'elevation' than seen on *Repulse*. Subsequently the port hull amidships is only partly buried, with the deck edge down to about two thirds the original waterline under the seabed, leaving the lower portion of the armour belt through port amidships clearly visible (unlike on *Repulse*). The port deck edge forward of A Turret remains held up off the seabed a little, while the very stern is basically flush with the seabed, or only 'just' buried. Therefore, given this relatively 'favourable' orientation of the hull, all the areas where torpedoes were reported to have hit *Prince of Wales* would be expected to be clearly visible *above* the seabed.

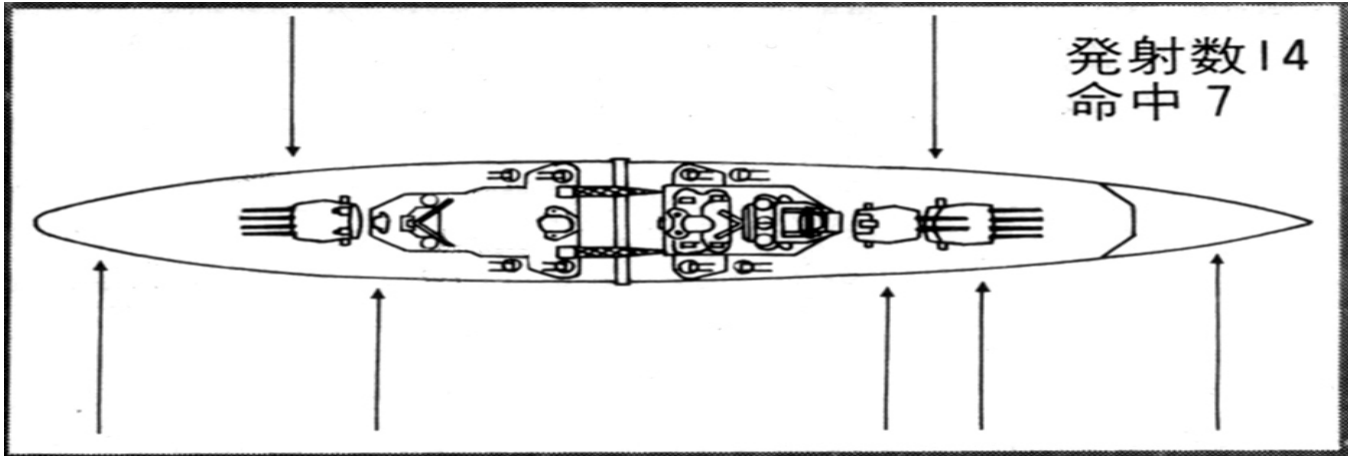
British accounts state that HMS *Prince of Wales* was hit by at least six torpedoes, four on the starboard side and two to port. Our survey results differ in the fact that we found only three large jagged holes to starboard and only one to port, and can categorically state that there are no 'jagged holes' where (two) torpedoes were reported to have hit on the starboard and port hull beneath the mainmast and the rear funnel respectively. The hull both fore and aft of this area is however 'dished in' longitudinally - from *about* Frame 170 to *about* Frame 282 on the starboard hull and *about* Frame 140 to *about* Frame 255 on the port hull - and is 'split' longitudinally along the base of the armour belt for quite some distance in those areas; and is 'crumpled' in places along there also. The damage observed along these two sections differs *dramatically* though from the gapping jagged holes in the four other areas where torpedoes have actually 'blown open' the hull.

Video survey footage shot along the entire *starboard hull* therefore confirms only *three* large jagged penetration holes centered at; 1) The very bow itself - *Frame 8* - so close to the bow stem that the stem itself is broken/fractured and the hole actually penetrates right through the ship from starboard to port; 2) Beneath B turret - *Frame 109* - just forward of the bridge; 3) The stern - *Frame 296* - *above* and slightly abaft the outer strut of the outer propeller shaft A-Bracket, i.e. higher on the hull than *all* the other torpedo holes, indicating that the surrounding area aft was already well submerged when this torpedo hit. Video survey footage shot along the *port hull* confirms only *one* large jagged penetration hole - *Frame 284* - which is at the stern between the port outer propeller shaft A-Bracket and where the port outer propeller shaft exited the hull. The same video footage however shows *no* jagged penetration holes whatsoever - as specifically seen in the above four areas - *anywhere* else along the port or starboard hulls and specifically *not* in the area around the mainmast or rear funnel where torpedoes were thought to have hit the ship.

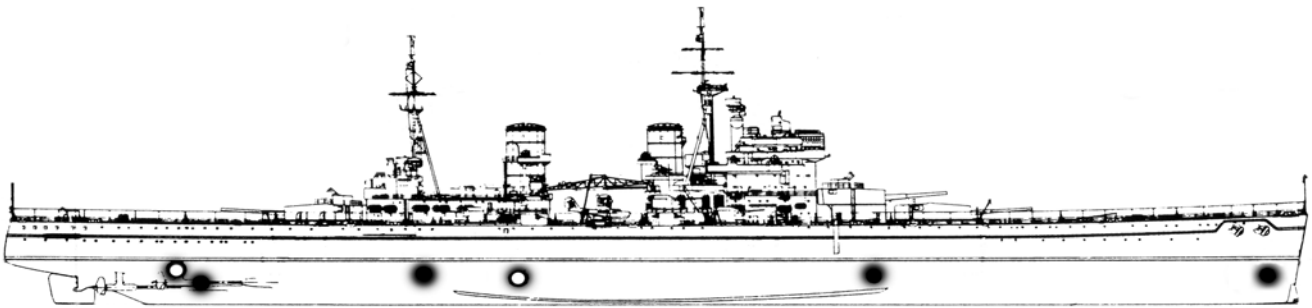
We spent a total of four days diving on *Prince of Wales*, with the visibility continuing to steadily deteriorate on a daily basis, until on the last day it was only about 3m/10ft or less.

Footnote: Video footage of the hull of *Prince of Wales* has since been forwarded to naval architects, marine engineers and historians worldwide and we await their assessment, particularly of the 'odd' damage documented between Frames 170 and 282 starboard and between Frames 140 and 255 port. As stated above, even though torpedo hits were reported in those areas there were no jagged torpedo 'holes' as we found elsewhere. What we have documented (on both wrecks) is *certainly* at odds with the historical record.

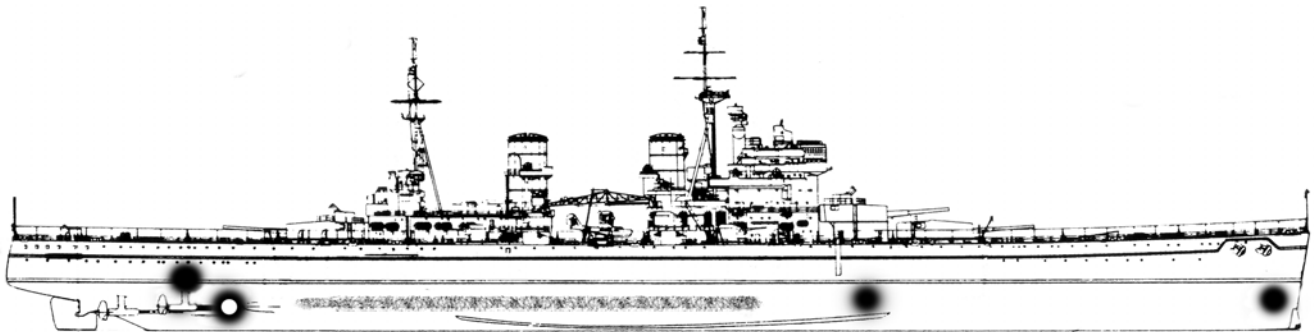
EXPEDITION 'JOB 74'



Arrows indicate where Japanese aircrews thought 7 of the 14 torpedoes launched at HMS *Prince of Wales* hit. (Above diagram as reported by Japanese sources.)



British sources record six torpedo hits, as shown above.
 Black solid circles on hull = Suspected starboard side torpedo hits.
 Black outline circles on hull = Suspected port side torpedo hits.



Expedition 'Job 74' could confirm only four hits, in the areas as shown above. If the hits reported beneath the mainmast and rear funnel actually struck the ship they have not penetrated the hull like the others have. However considerable indentation exists on both sides of the ship along the entire length of the shaded grey area - shown above - with longitudinal splitting in some parts in this area, right beneath/along the armour belt base.
 Black solid circles on hull = Confirmed starboard side torpedo hits.
 Black outline circle on hull = Confirmed port side torpedo hit.
 Torpedo hole *height* Stbd aft indicates just how far stern had already *settled* when hit!

EXPEDITION 'JOB 74'

The confirmed location of all four hits



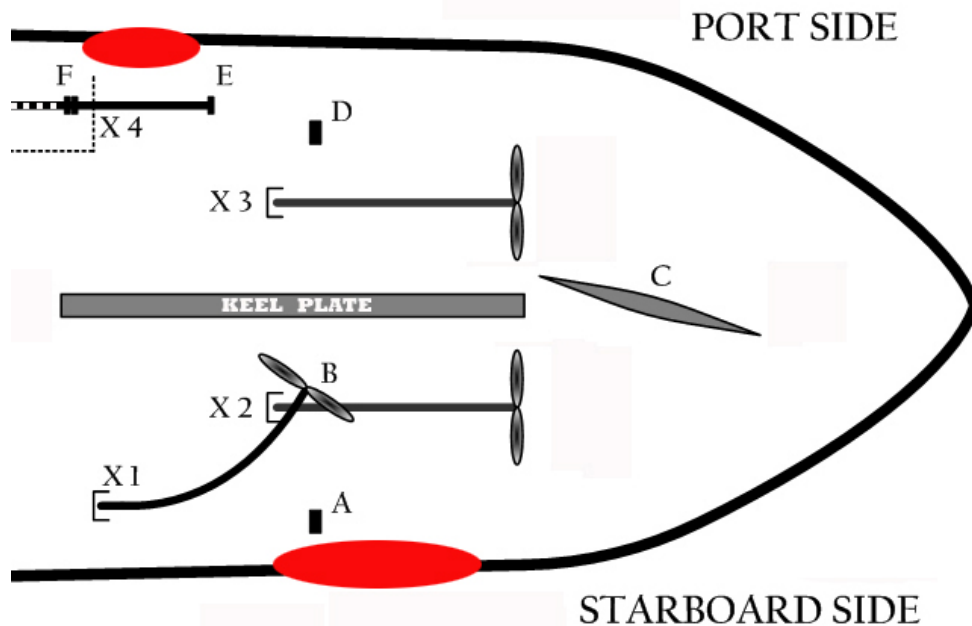
3D image of HMS *Prince of Wales* courtesy Stefan Draminski



A Japanese WW11 painting depicting a torpedo striking the stern HMS *Prince of Wales*. It took four such hits & 100 minutes for the pride of the British Navy to capsize and sink.

EXPEDITION 'JOB 74'

H.M.S. PRINCE OF WALES Upside-Down Stern Section - Propeller Shafts Details From Survey by Divers May 2007



Not To Scale

For Diagrammatical Purpose Only

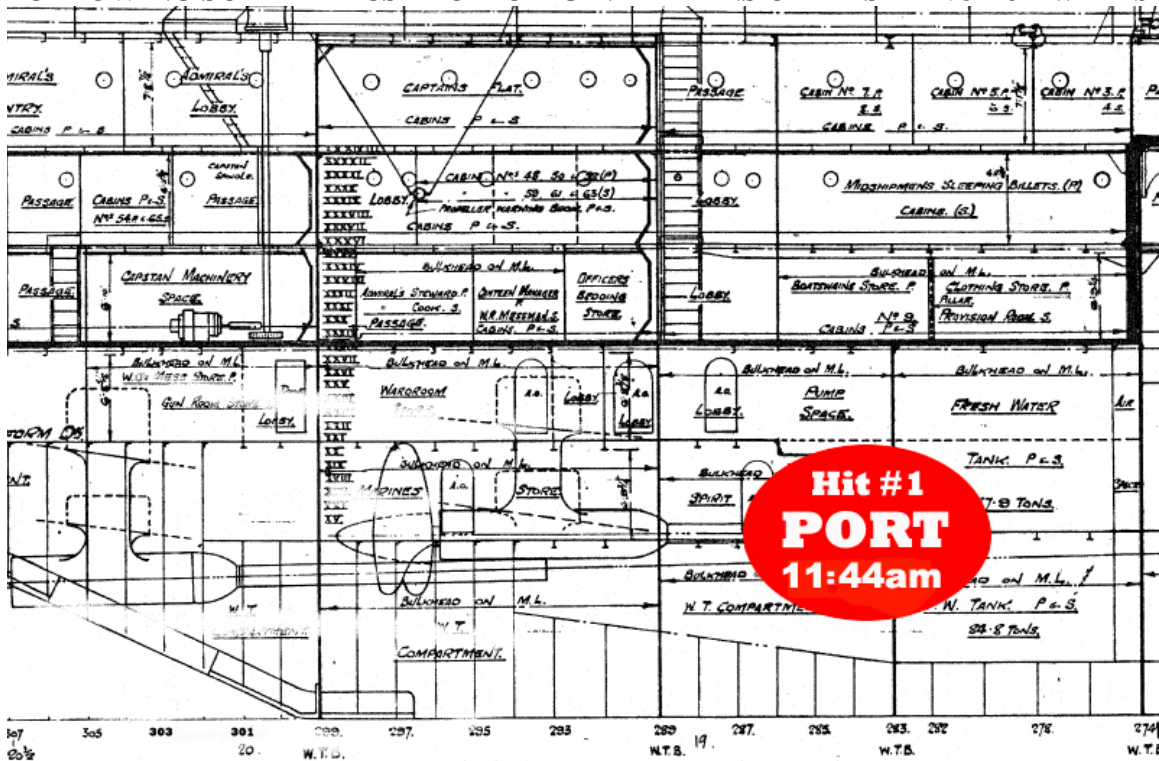
NOTE: Port & Starboard Torpedo Holes

Illustration by Enoch Denlay

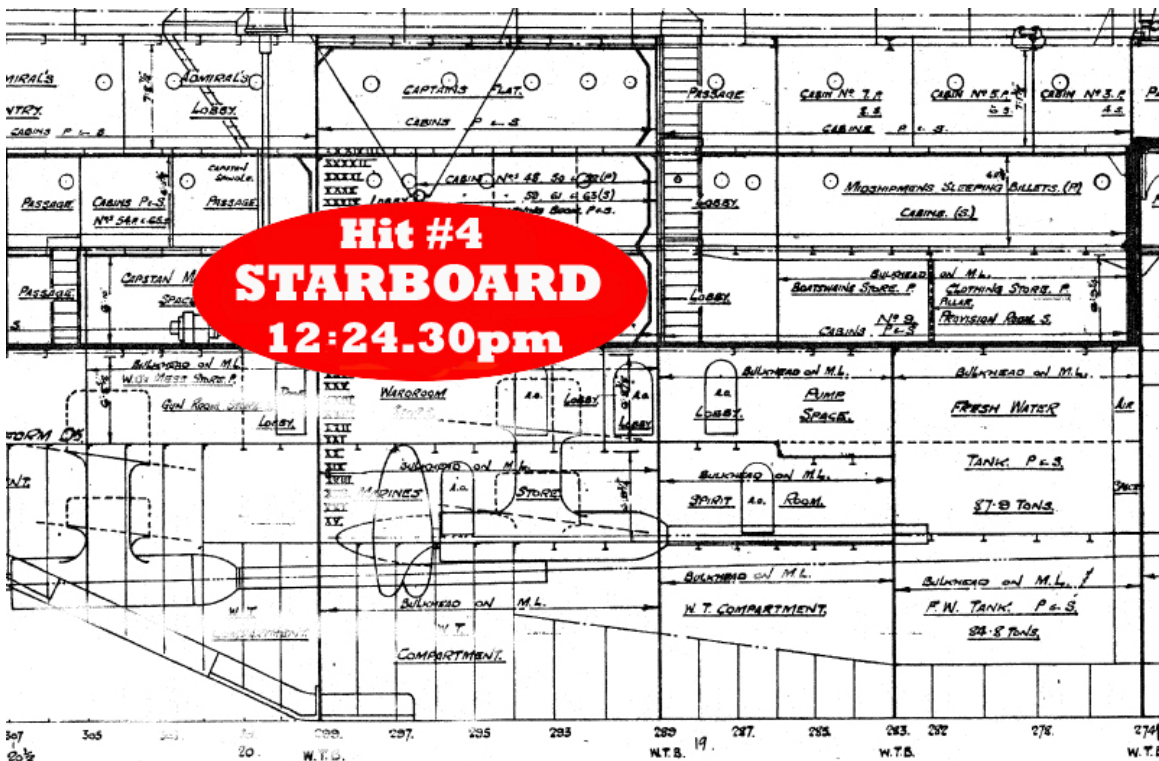
- A) Remains of the *outer* strut of the outer Starboard shaft A-Bracket.
 - B) Outer Starboard propeller shaft is bent inboard and its propeller rests 'atop' the inner shaft just aft of where inner shaft exits the hull at the stern tube gland.
 - C) Rudder is angled to port at approximately 20 degrees.
 - D) Remains of the *inner* strut of the outer Port shaft A-Bracket.
 - E) Flange on end of outer Port shaft (propeller, A-Bracket and shaft length missing).
 - F) The flange that joins two lengths of shaft that can be seen when looking forward along the shaft inside the damaged stern tube receptacle.
- X1, X2, X3. Positions where shafts exit the hull at the stern tube gland.
X4. Where the Port shaft stern tube gland exit point is *thought* to have been. Severe damage to this area has made marking the exact position, in relation to the remaining shaft, difficult. Red elliptical areas on either side show position of torpedo hits/holes. Hole on Port is approximately 4 mts high by 6mts wide and was the first hit the ship took, while the hole on Starboard is approximately 4mts high by 11mts wide and was the fourth, or last, torpedo hit the ship took. (Time between hits, approx. 40 minutes.)

EXPEDITION 'JOB 74'

FOLLOWING SCHEMATICS FROM ORIGINAL PLANS OF HMS PRINCE OF WALES

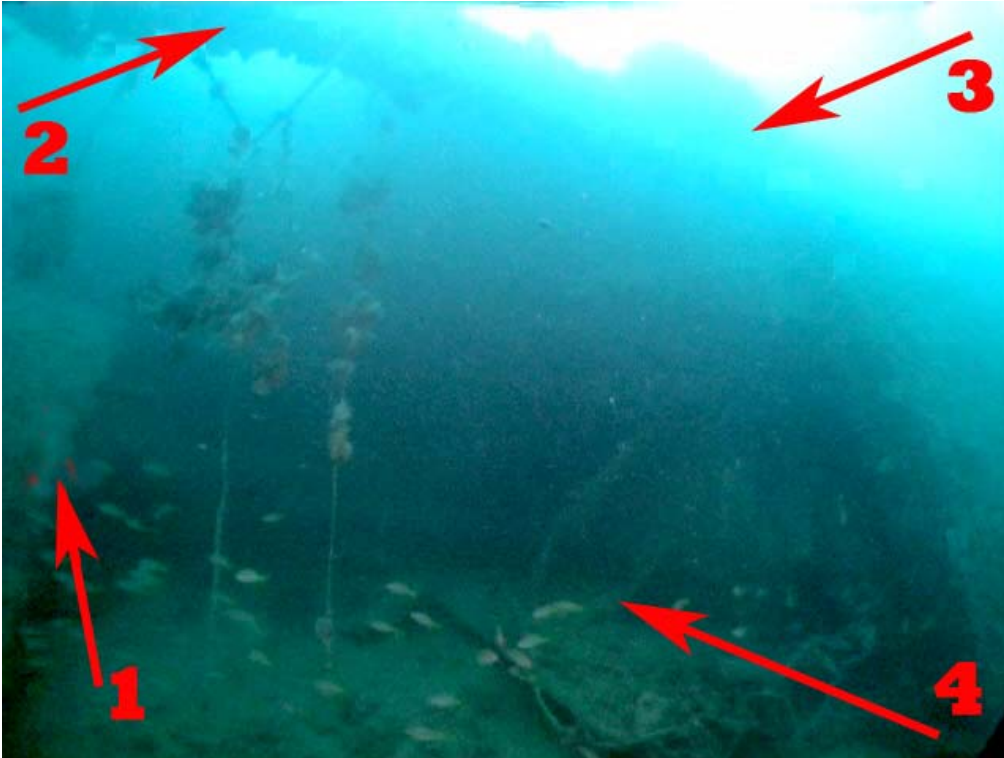


ABOVE: Port side hit aft centered at about Frame 284 is approx 4m high x 6m wide. Please note; this is a 'starboard side plan' but shows the PORT side hit position on hull.



Starboard side hit aft centered at about Frame 296 is approx 4m high x 11m wide.

EXPEDITION 'JOB 74'

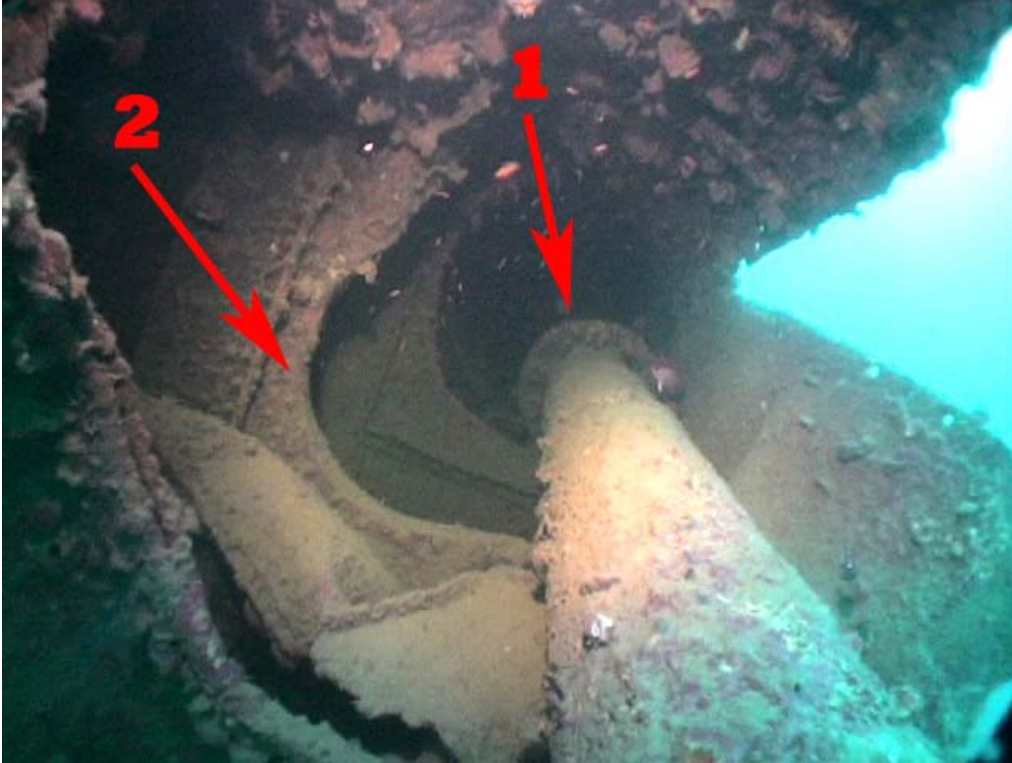


1) Edge of an inward collapsed hull plate. 2) Outer Port propeller shaft. 3) Location of split in hull where shaft exited stern tube. 4) Main opening of torpedo hole. Above 4 is forward edge of hole. Hole dimensions approx 4 meters high by 6 meters wide.

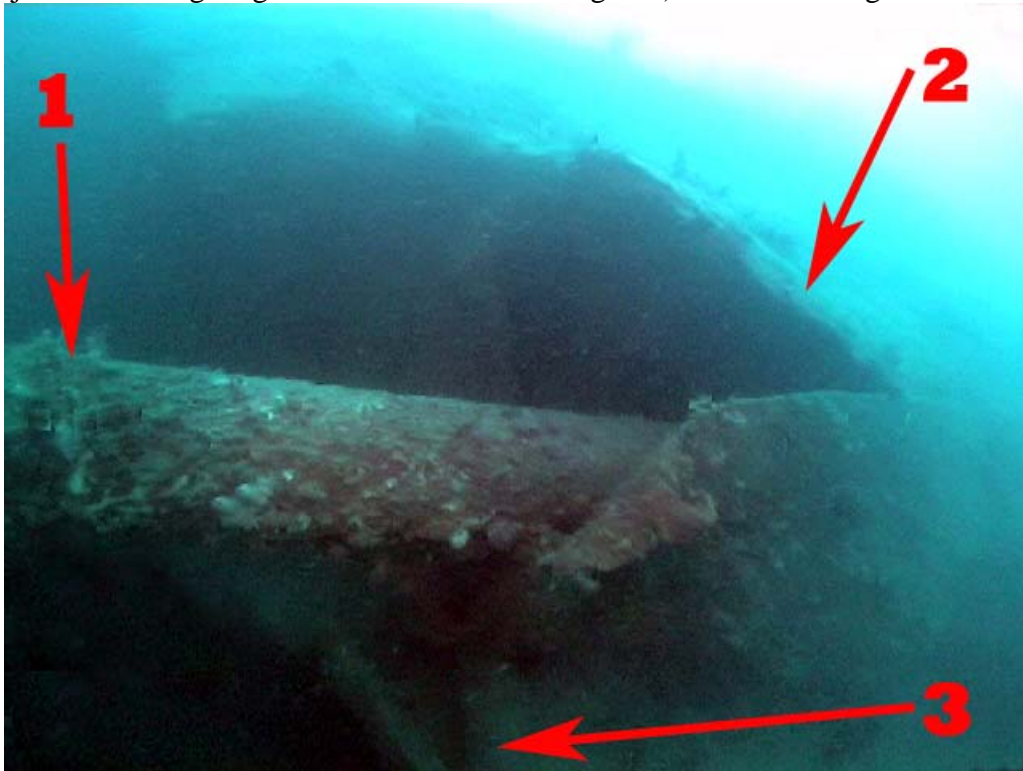


1) Aft end of same inward collapsed hull plate marked 1 in above image. 2) Main opening of hole. 3) Outer Port propeller shaft. 4) Flange on end of outer Port shaft.

EXPEDITION 'JOB 74'

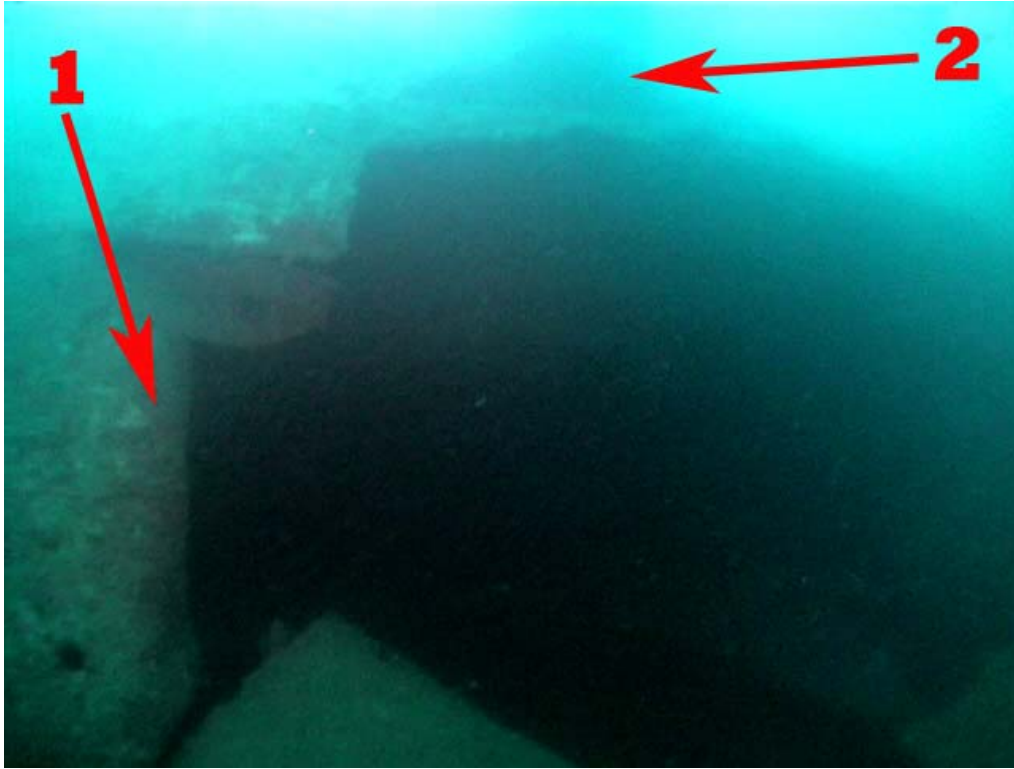


Looking forward from forward edge of torpedo hole into stern tube receptacle. 1) Flange that joins extruding length of shaft to an inner length. 2) Distorted/elongated web frames.



1) Outer Port propeller shaft. 2) Split in hull thought to be from shaft rotating out of center / flailing, etc., after the torpedo hit. 3) Forward edge of Port torpedo hole.

EXPEDITION 'JOB 74'

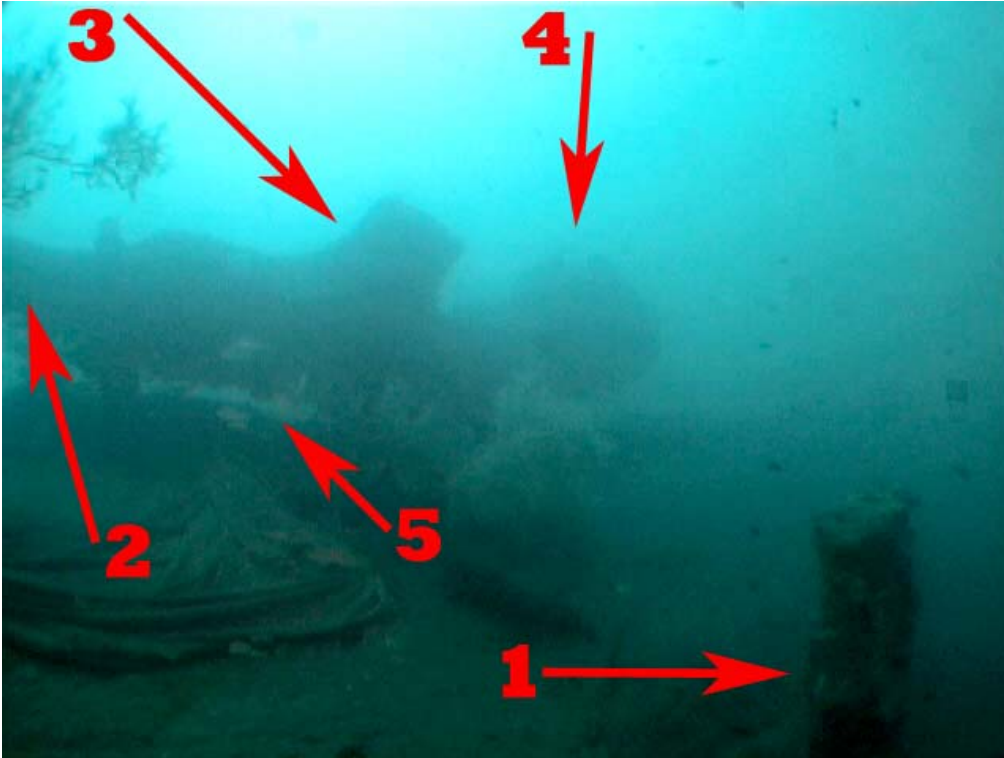


1) Forward edge of Starboard torpedo hole. 2) *Outer* strut stub from outer shaft A Bracket.

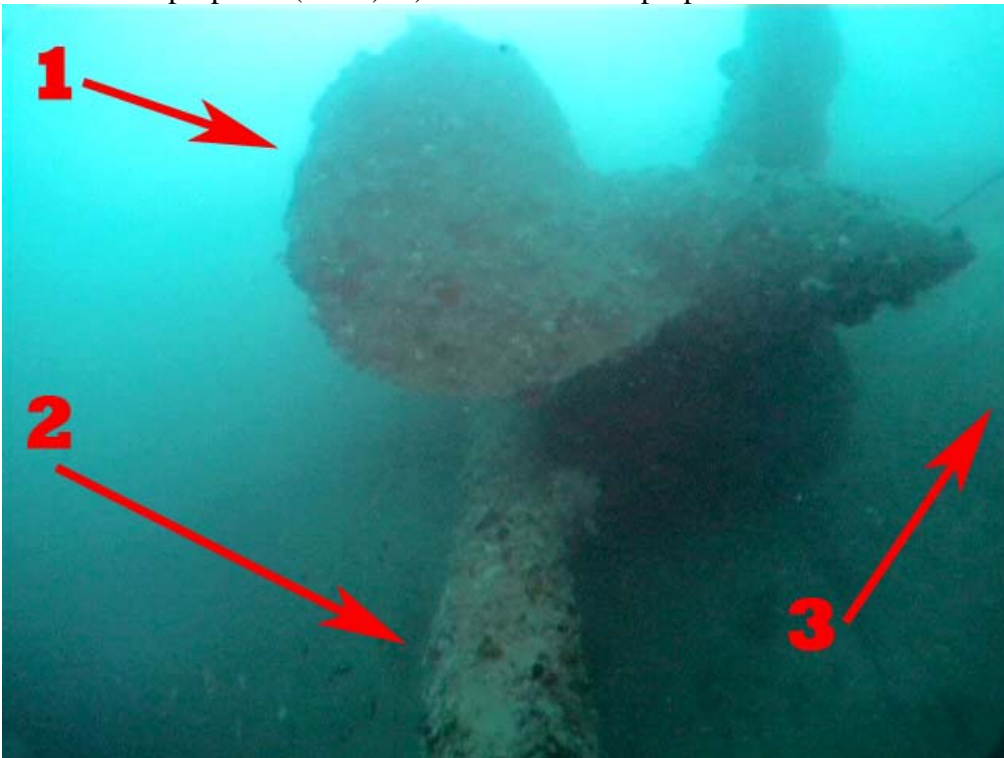


1) The height of hole in hull can be judged by how close it comes to the row of scuttles / portholes. This was by far the highest location of any of the hits and infers just how far the stern had settled in the forty minute interval between Port and Starboard aft hits. 2) Aft edge of torpedo hole. Dimensions are approximately 4 meters high by 11 meters wide.

EXPEDITION 'JOB 74'

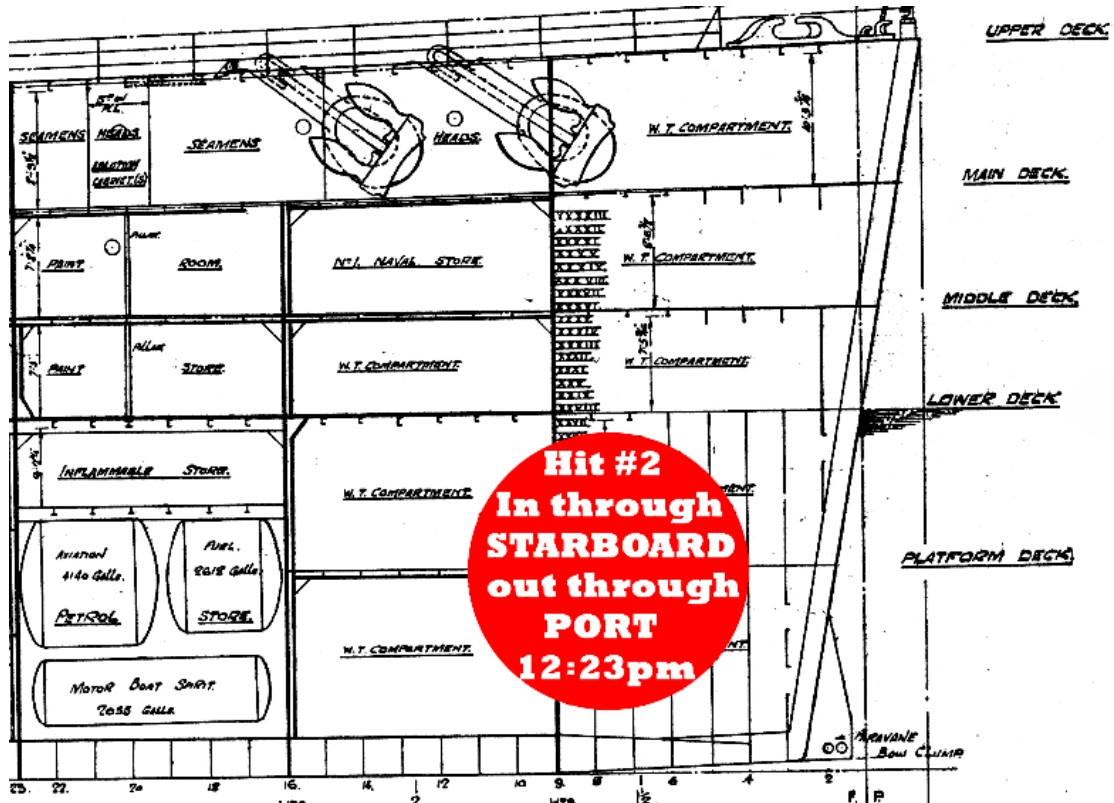


- 1) Only a short stub remains of the *outer* strut of the *outer* Starboard shaft A-Bracket. 2) Outer propeller shaft. 3) Remains of outer strut of outer A-Bracket that was joined to *1*. 4) Outer Starboard propeller (blade). 5) Inner Starboard propeller shaft where it exits gland.

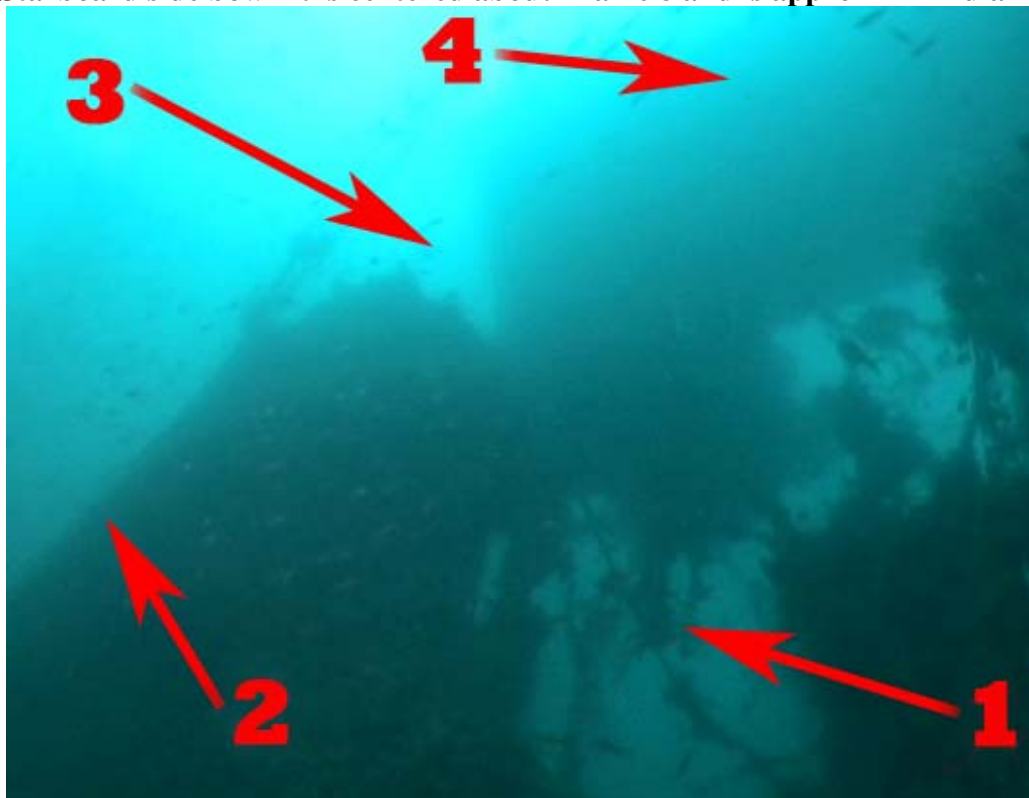


- 1) Outer Starboard Propeller. 2) Inner Starboard propeller shaft. 3) Center Keel Plate.

EXPEDITION 'JOB 74'

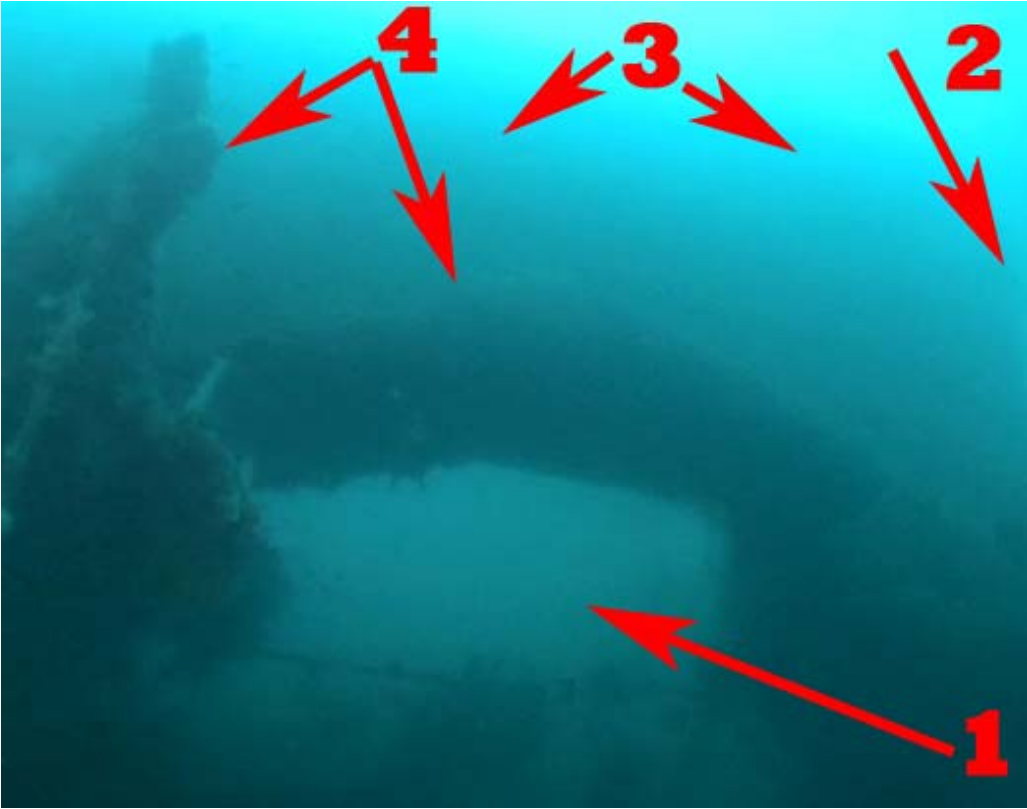


Starboard side bow hit is centered about Frame 8 and is approx 7m in diameter.

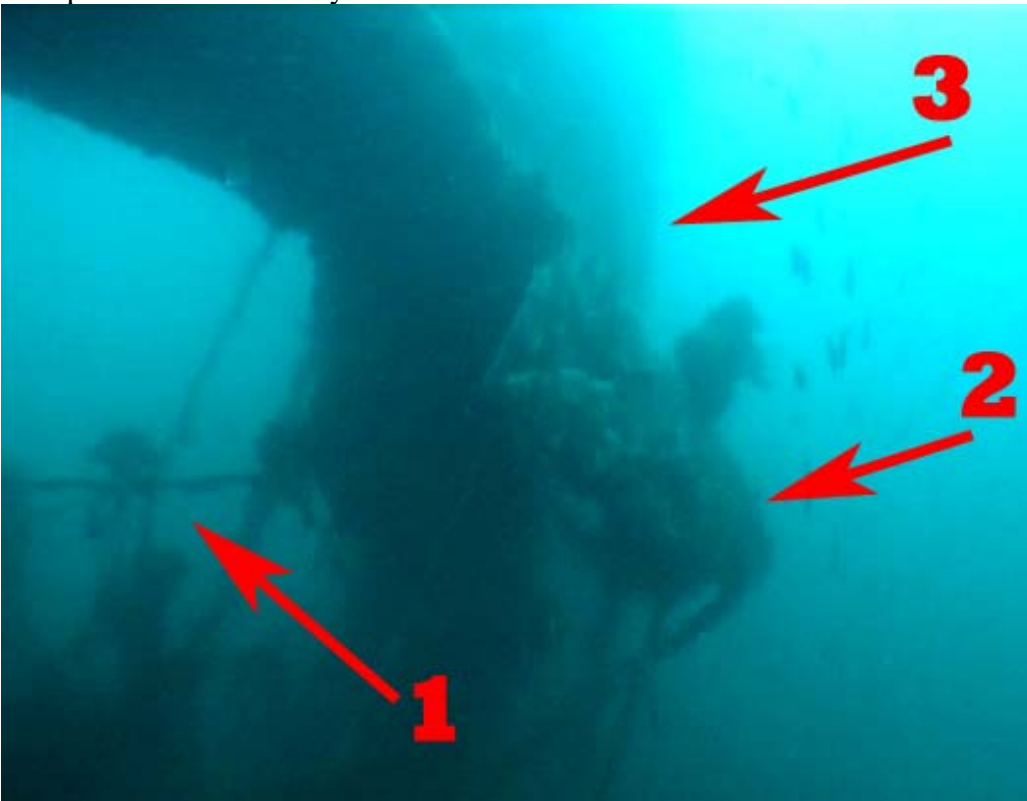


1) Forward portion of torpedo hole viewed from Starboard. 2) Bow stem. 3) Break in bow stem-post. 4) Bow stem below break (*below* when ship was upright that is).

EXPEDITION 'JOB 74'

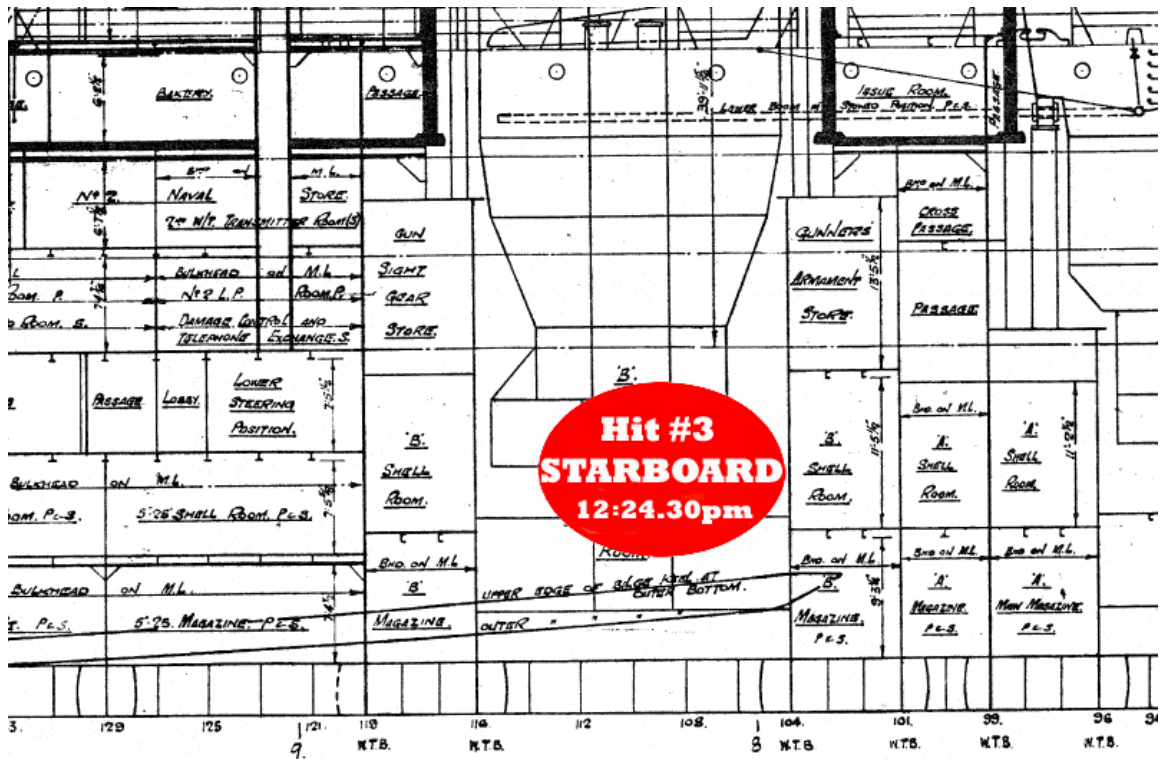


1) Torpedo hole viewed from Port side. 2) Bow stem. 3) Center Keel – bottom - of ship. 4) Hull plates bent noticeably out to Port from force of Starboard hit.

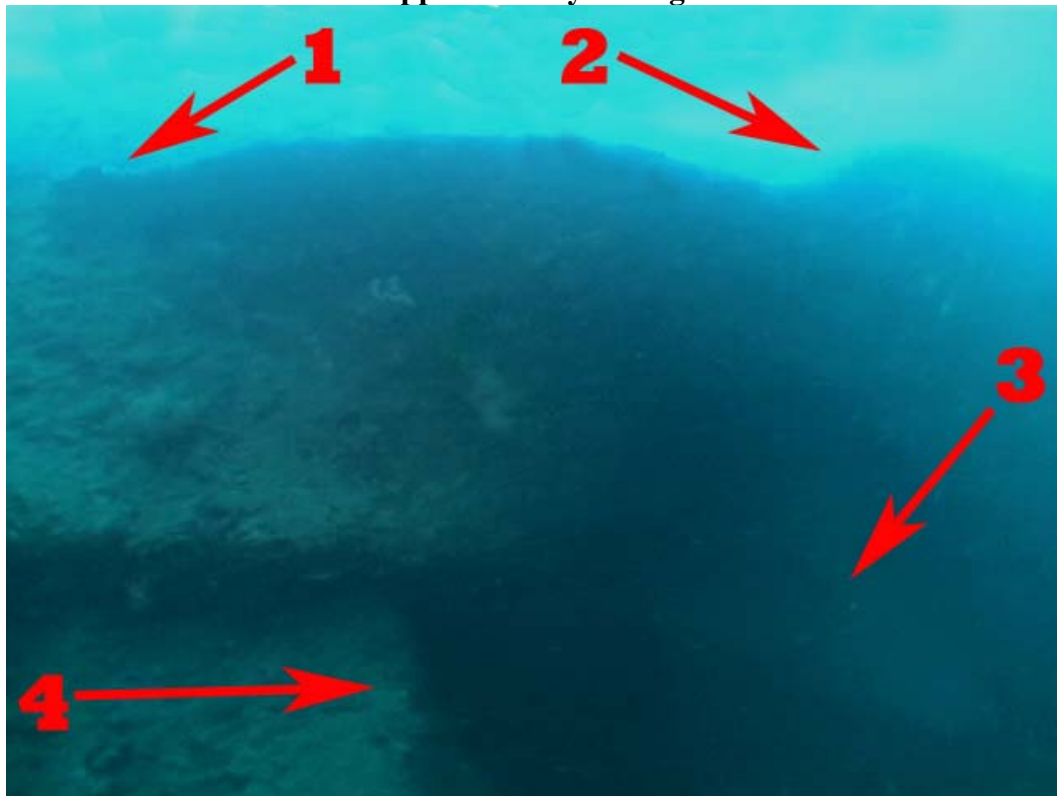


1) Torpedo hole. 2) Hull plate at forward edge of hole bent out to Port. 3) Bow stem.

EXPEDITION 'JOB 74'

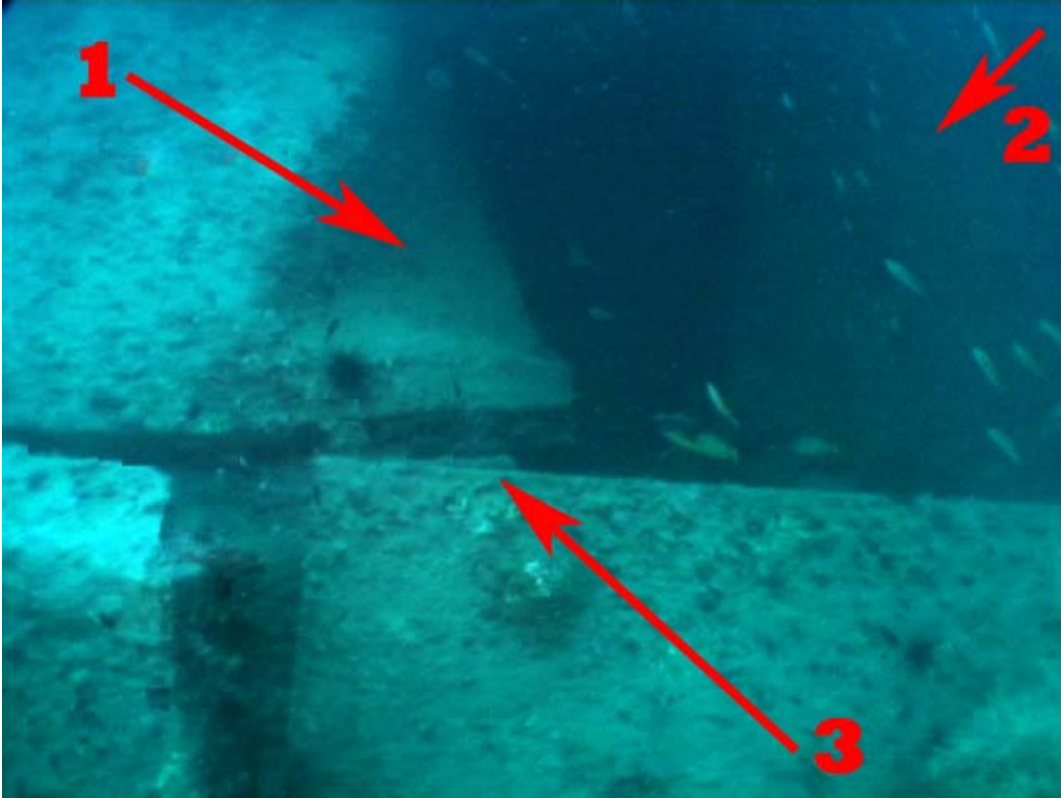


Starboard side hit forward is just forward of the Bridge and outboard of B Turret, centered about Frame 109 and approximately 4m high x 6m wide.

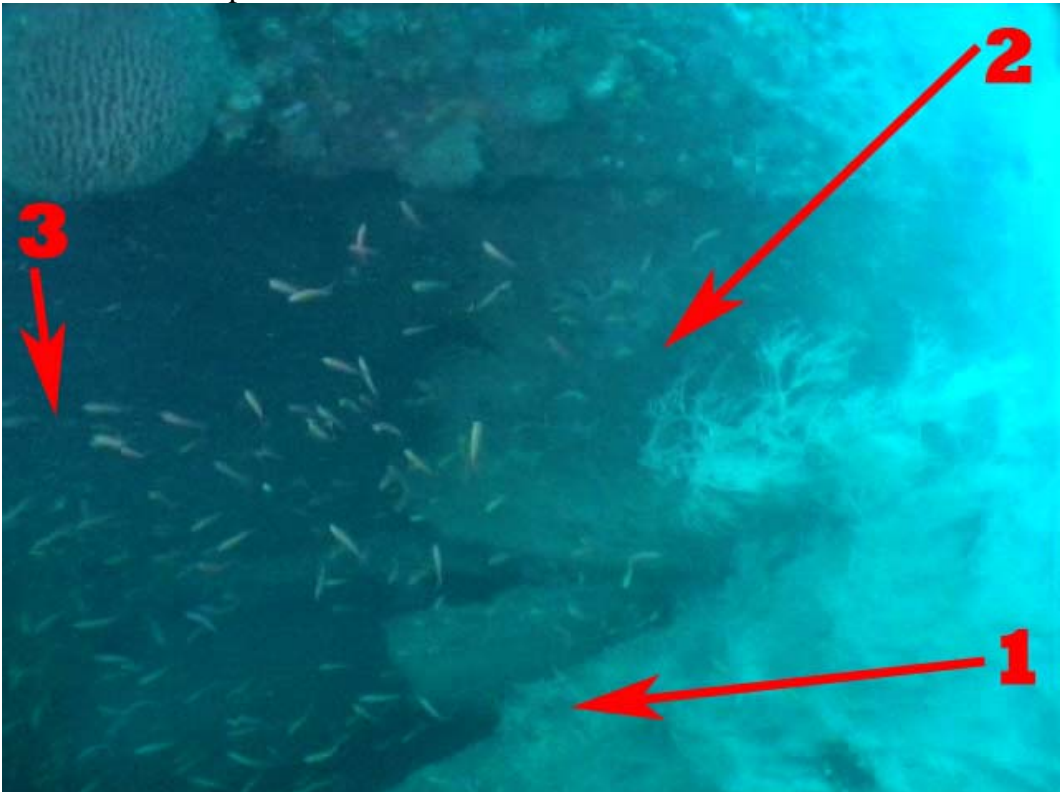


1) Forward end of Starboard Bilge Keel. 2) Buckle in Bilge Keel above torpedo hole. 3) Upper portion of torpedo hole. 4) Forward edge of torpedo hole.

EXPEDITION 'JOB 74'



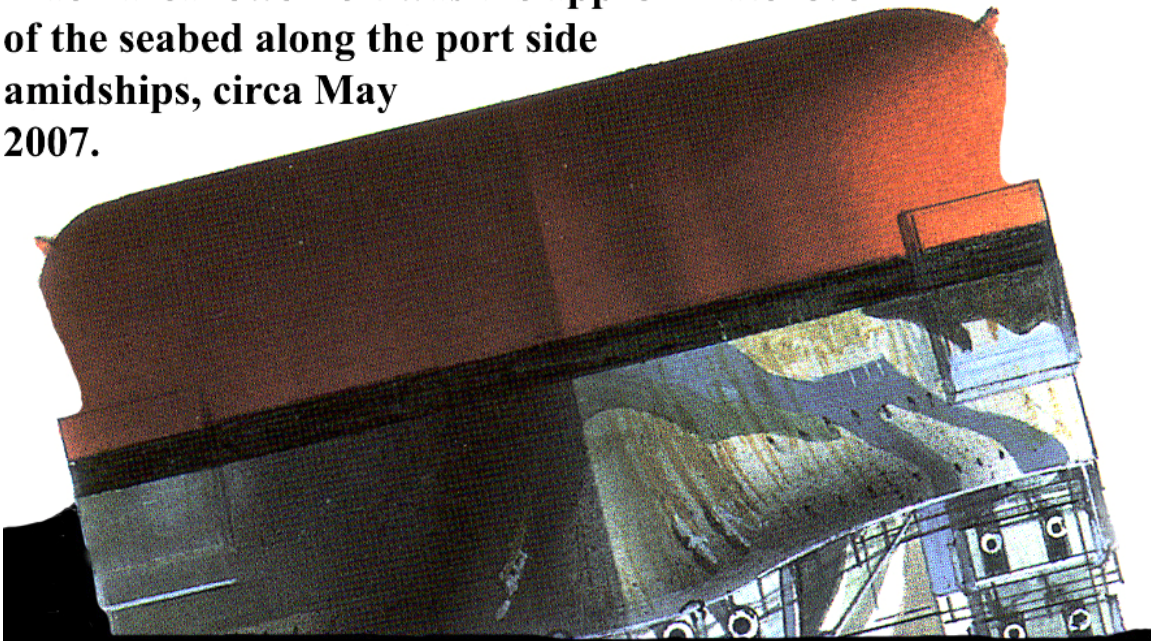
1) Bent in plate, lower forward edge of torpedo hole. 2) Lower portion of hole. 3) Bottom edge of Armour Belt plate.



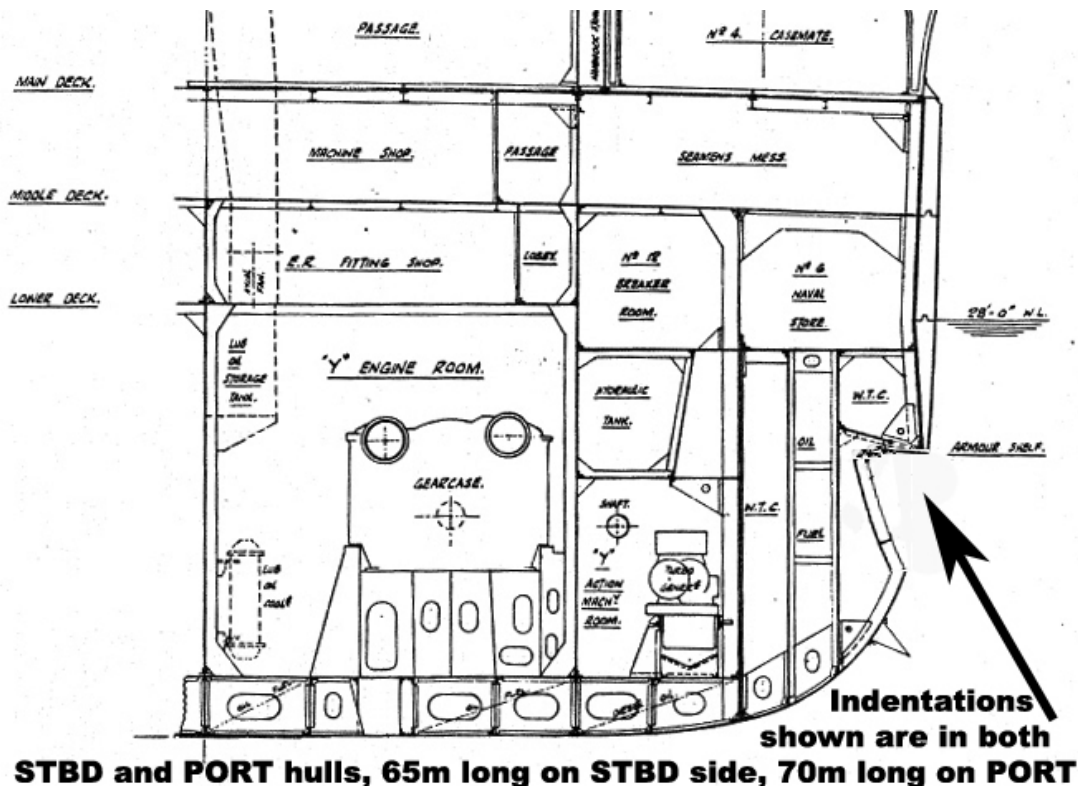
1) Bottom edge, Armour Belt. 2) Bent in hull plates, aft edge of hole. 3) Torpedo hole.

EXPEDITION 'JOB 74'

Black area lower left was the approximate level of the seabed along the port side amidships, circa May 2007.



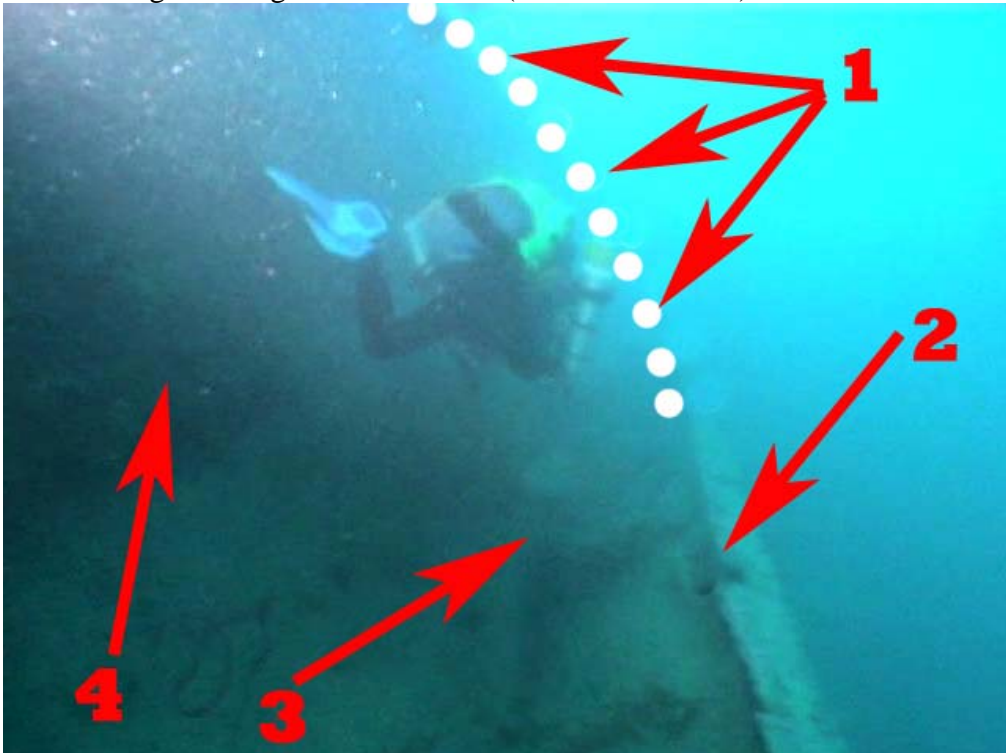
WRECK OF *PRINCE OF WALES* LAYS ON AN ANGLE OF APPROX. 15° TO PORT. Concave indentations in hull below armour belt are shaped as above throughout the areas as described in paragraph at bottom of page 9. This damage, and more information on the stern damage, is discussed - and shown in more detail - in two separate reports accessed at bottom of linked page; http://www.pacificwrecks.com/ships/hms/prince_of_wales.html



EXPEDITION 'JOB 74'



Diver swimming aft along hull indentation (on Starboard side) at about the widest point.



1) White dots follow a line that hull curvature *should* take, i.e. convex. 2) Bottom edge of Armour Belt plate. 3) Edge of lower hull plate (running fore and aft) that has *pulled away* from Armour Belt. 4) Lower hull plates below Armour Belt now concave; they should be convex. This deformation stretches for 65 meters on Starboard hull & 70 meters on Port.

EXPEDITION 'JOB 74'

Results of Objective 2.

Because of the poor visibility (and low ambient light) encountered on both wrecks, which at the start of the expedition when we first dived on *Repulse* was at most about 8m/25ft on the seabed, and which continued to deteriorate until the last days on *Prince of Wales* when it was only about 3m/10ft or less in parts, it was not possible to shoot the type of video footage necessary for making a photo mosaic.

Results of Objective 3

Dr Andrew Fock conducted daily visual acuity tests on all divers using a Snellen chart and various strength diopter lenses to quantify any refractive change in vision that may be attributed to Hyperoxia Induced Myopia, and a summary by Dr Fock is attached as an appendix to this report.



Results of Objective 4

Dr Andrew Fock conducted daily pulmonary tests using a Spirometer to ascertain any changes in pulmonary functionality that may be attributed to the high levels of oxygen that the divers were exposed to, and the subsequent oxygen 'loading' that was 'accruing' in their bodies on a daily basis over the period of the expedition, and a summary by Dr Fock is attached as an appendix to this report.



EXPEDITION ‘JOB 74’

Appendix A:

Medical Aspects to Expedition ‘Job 74’

The toxic effects of oxygen on the lungs was first described by Lorraine-Smith[1] in the late part of the 19th Century. This was further quantified by the Royal Navy[2] during the second world war and the United States Navy[3] post war. However, these studies were conducted using single exposures. In the 1980’s Hamilton et al [4] developed the REPEX (repetitive exposure) tables for dealing with repeated exposures to high levels of oxygen encountered in deep sea habitats. This has been extrapolated to estimate pulmonary oxygen toxicity for sequential oxygen exposures in recreational diving, but, to the researchers knowledge, has never been validated in recreation technical divers. Technical divers using CCR SCUBA (Closed Circuit Rebreather Self Contained Underwater Breathing Apparatus) are particularly at risk of oxygen toxicity from repeated exposure. This is because the apparatus maintains a high level of oxygen (usually 1.3 ATA) for the duration of the dive. Additionally, technical divers will often use pure (100%) oxygen for the final part of the dive to reduce decompression times. During a recent self reporting health survey of this group of divers during an 8 day technical diving expedition, we detected symptoms suggestive of pulmonary oxygen toxicity in 50% of the divers. These symptoms commenced between day 4 and day 6. This study aims to quantify pulmonary oxygen toxicity in a similar group of technical divers performing a series dives during several diving expeditions conducted in 2007.

Serial basic respiratory function tests are performed on a daily basis (including pre and post expedition) to assess any decrement in pulmonary function. These tests are of a non invasive nature involving basic spirometry with the results stored onto a laptop computer in a suitable data base. Tests are performed at approximately 4 hours post dive. Oxygen exposure are derived by interrogation of the divers dive computers to calculate the partial pressure of oxygen multiplied by the time of exposure in minutes as described by Bardin et al[5]. All participants are also asked to complete a health survey at the completion of each days diving. As divers have also reported changes in Visual Acuity when exposed to repeated high oxygen levels (Hyperoxic Induced Myopia), each diver is asked to record changes in their eye sight using a Snellen visual acuity chart and a series of corrective lenses. This test is performed each morning prior to diving with the observer recording the lens value (in dioptres correction) which produced the clearest vision for each diver and each eye. Results will be published in an appropriate Hyperbaric and Diving journal (probably Diving and Hyperbaric Medicine). It is hypothesised that information gained from this research will enable us to make suitable recommendations about limiting oxygen exposure in this group of divers as well as recovery times from repeated oxygen exposure.

Statistical Analysis

All analysis will be performed using SAS version 8.2 (SAS Institute Inc., Cary, NC, USA.). Univariate analysis will be conducted using paired t-tests for normally distributed outcomes and Wilcoxon sign rank tests should the outcomes be found to follow non-parametric distributions. Multivariate analysis will be performed using generalized linear modeling adjusting for repeat measures and potential covariates. Results will be further validated by considering changes from baseline.

EXPEDITION 'JOB 74'

Sample size

Whilst the exploratory and descriptive nature of this study should reduce the need for formal power calculations, with a minimum of 8 subjects this study will have an 80% power to detect an effect size of 1.4 standard deviations with a two-sided p-value of 0.05.

1. Lorrain-Smith, J., *The pathological effects of increase of oxygen tension in the air breathed*. Journal of Physiology (London), 1899(24): p. 19-35.
2. Donald, K., *Oxygen and the diver*. 1992: Best Pub Co.
3. Lambertsen, C.J., et al., *Definition of tolerance to continuous hyperoxia in man: An abstract report of predictive studies V*, in *Underwater and Hyperbaric Physiology IX*, A.A. Bove, A.J. Bachrach, and L.J. Greenbaum, Editors. 1987, Undersea and Hyperbaric Medical Society: Bethesda Maryland. p. 717-749.
4. Hamilton, R.W., et al., *REPEX: Development of Repetitive Excursions, Surfacing Techniques, and Oxygen Procedures for Habitat Diving*. 1988, NURP Technical Report 88-1A.
5. Bardin, H. and C.J. Lambertsen, *A quantitative method for calculating pulmonary oxygen toxicity. Use of the "Unit of Pulmonary Toxicity Dose" (UPTD)*, in *Institute for Environmental Medicine Report*. 1970, University of Philadelphia: Philadelphia.

Appendix B:

Medical results from Expedition 'Job 74':

The results for this expedition are part of the overall study which involves 30 divers and three expeditions. As such formal analysis of the results from this part of the study have not yet been conducted. However, the following observations were made:

- Despite symptoms consistent with pulmonary oxygen toxicity, no consistent decrement in pulmonary function was observed (subject to statistical confirmation).
- Symptoms were worse if the divers were using open circuit surface supplied oxygen at the final decompression stops rather than remaining on their CCR units.
 - This may have been due to the dry gas breathed when using open circuit?
- No significant decrement in visual acuity was noted using the methods described in appendix A. However, due to the restrictions of the vessel, a modified Snellen chart at 3 metres instead of 6 metres was used. This may have confounded the results as several divers still complained of symptoms of HIM.
- Despite several divers exceeding the REPEX limits and the NOAA daily Oxygen limits, no Central Nervous System toxicity symptoms were observed.
- Despite repeated dives in the "Extreme Exposure" range of the diving tables, very few symptoms of decompression sickness were observed and those that were seen were treated with in-water recompression with excellent results.

Dr. Andrew Fock MB;BS FANZCA Dip DHM
July 2007

EXPEDITION 'JOB 74'



Dr Andrew Fock (left) and Explorers Club member Kevin Denlay (FI98) with their respective Closed Circuit Rebreathers and Explorers Club Flag 118 aboard MV *Empress* at the successful completion of Expedition 'Job 74'.



Diver Propulsion Vehicle, with video camera and lights swivel mounted for wreck survey.

EXPEDITION 'JOB 74'

Bibliography

- Ash, Bernard. *Someone Had Blundered*. Garden City, New York, Doubleday, 1961.
- Brown, D. K. *Nelson to Vanguard. Warship Design and Development 1923 - 1945*. Annapolis, Maryland, Naval Institute Press, 2006.
- Brooke, Geoffrey, *Alarm Starboard: A Remarkable True Story of the War at Sea*. Cambridge, Patrick Stephens, 1982.
- Bueschell, R. *Mitsubishi G3M1/2/3 96 Rikko in Japanese Naval Air Service*. Atglen, PA, Schiffer Publications, 1997.
- Chesneau, Roger. *King George V Class Battleships*. Oxford, Osprey Publishing, 2003.
- Churchill, Winston S., *The Second World War, Volume 3: The Grand Alliance*, Boston, Houghton Mifflin Co., 1950.
- Garzke, William H., Jr. and Dulin, Robert O., Jr., *Battleship: Allied Battleships of World War II*. Annapolis, Maryland, Naval Institute Press, 1980.
- Grenfell, Russell. *Main Fleet to Singapore*. UK, Faber and Faber, 1951; Singapore, Oxford University Press, 1987.
- Hamer, D. *Bombers Versus Battleships. The Struggle Between Ships and Aircraft for the Control of the Surface of the Sea*. London, Conway Maritime Press, 1999.
- Marder, Arthur. *Old Friends, New Enemies*. Oxford, Clarendon Press, 1981.
- McIntyre, David. *The Rise and Fall of the Singapore Naval Base*. Hamden, Archon Books, 1979.
- Middlebrook, M. and Mahoney, P. *Battleship. The Loss of the Prince of Wales and the Repulse* London, Penguin Books, 1977.
- Hough, Richard, *The Hunting of Force Z: Britain's Greatest Modern Naval Disaster*. London, Collins, 1963.
- Nicholson, Arthur, *Hostages to Fortune: Winston Churchill and the Loss of the Prince of Wales and Repulse*. Gloucestershire, Phoenix Hill, 2005.
- Roberts, John and Raven, Alan. *British Battleships of WW11*. London, Arms and Armour Press, 1976.
- Tagaya, O. *Mitsubishi Type 1 Rikko 'Betty' Units of World War 2*. Oxford, Osprey Publishing Limited, 2001.
- Tarrant V. *King George V Class Battleships*. London, Arms and Armour Press, 1991.
- Whitley, M. J. *Battleships of World War Two. An International Encyclopaedia*. London, Arms and Armour Press, 1998